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Knowledge, research and innovation systems and developing countries[1]

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In the first part of this paper, we offer a general approach to national research systems, or better (as we will argue), knowledge, research and innovation systems (KRIS). In the second part, we argue that developing countries need not imitate the system of one or another developed country, but can "grow their own KRIS". In the third part, we identify constraints and opportunities to do so.

Part I: evolving research systems

Analysis in terms of (national) systems is generally recognized as important, and this has justified studies of (national) research systems since the early 1980s (by OECD) and of national innovation systems, as well as regional and sectoral innovation systems. By now, the two have merged into study of, and policy for, research and innovation systems (RIS). There has not always been enough attention to the system character, though, and studies are then reduced to lists of institutions and/or a history at the national level.

Speaking in terms of a (national) system implies that there are mutual dependencies between the various organisations and activities involved in research and innovation (and knowledge production), which can be studied in terms of their capacities, and how these add up to capacity at the system level. Over time, as the case studies in the National Systems of Innovation literature clearly indicate (e.g. Nelson 1993), the mutual dependencies help creating a path in the overall development of the system. Such path-dependency may lead to continuation of system features which may be more or less productive.

If one accepts the systems approach, and the notion of a developmental path of a (national) system, one can enquire into the historical development. In particular, the emergence of the modern research (and innovation) system in Europe, USA and Japan, since 1870 (cf. Rip and Van der Meulen 1996). While the structures and cultures are not uniform across these countries, there are definitely overall similarities which allow us to speak of the modern research system. A system which is productive given how it is embedded in modern societies (including informal interactions and political culture).

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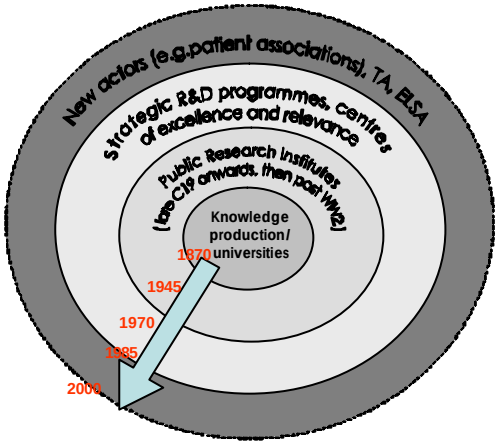
We elaborate the idea of a developmental path by first showing how this occurred for modern research systems. One aspect is how, over time, new types of institutions and interactions appeared. The Figure below visualizes this, starting in the late 19th century, at the time that research universities emerged and national governments started to consider research and higher education as topics of policy and "endowment", and then indicating briefly the institutions in the subsequent layers of the system.



In the Figure, the layers of can be seen as bridging the gap between academic knowledge production and society ever further. Practices and routines have developed for the working of such a system, and one could argue that all layers have to be present to have a well-functioning research system (Rip 2003). Thus, there is a basis for a diagnostic instrument, at least for modern research systems which are strongly institutionalized.

In general, if the notion of a well-functioning system is floated, this is often linked with a diagnosis of the present system falling short, and this then leads to attempts to modify the system. In Europe for example, the research and innovation system of the USA is often (and misguidedly) taken as the model of how things should be done. Thus, there is a question of a standard against which the actual functioning can be assessed. This requires analysis and understanding of longer-term developments. The present success of the USA might be linked not to the importance of mobility and competition in general, but to the fit between the US mobility and competition patterns and the presently dominant life sciences and biomedical sciences.

For developing countries it is tempting to refer to the research and innovation systems in Europe, USA and Japan (the TRIAD countries) as a standard, as a model to emulate, given their (still) leading role in the world. But this will introduce limitations in the study of (national) research and innovation systems in developing countries. For one thing, because most developing countries cannot aspire to achieve the same type of

research and innovation system as in the TRIAD countries, and have to be selective and identify alternatives. For another, having one standard (or ideal) for national research and innovation systems will background the variety which is out there. Capacity for variety is needed to respond to the particular circumstances of a country or region.

In other words, an example of a well-functioning system elsewhere cannot be simply be taken up (as a goal to be achieved) in developing countries. An own system has to be "grown" and improved. In other words, as we will discuss later (in part II), a mixture of selective uptake and adaptation of models and approaches from elsewhere, included in the efforts to learn from own experiences, is in order.

There is a practical and conceptual challenge: is a systems approach possible and useful in situations which are not strongly institutionalized?[4] Or alternatively, should one envisage institutionalization, but not in the way presupposed in the idea (and reality) of modern research & innovation systems? There are good reasons to consider the latter view (cf. also the perceptive opening chapter in Gaillard et al. 1997). If so, it would imply that it is necessary to reconstruct developmental paths by taking the actual institutionalizations into account, rather than mirror the path of the modern research & innovation system.

Thus, it is necessary to recognize that alternative developmental paths occur, and that such paths can lead to systems that are productive in their own right. To do justice to the possibilities of alternative paths, however, it is necessary broaden and have a more integrated notion of system, which includes knowledge production in general, as well as informal interactions. That is why we will speak of Knowledge, Research and Innovation Systems (KRIS).

The emphasis on knowledge refers to knowledge products as well as competencies and skills in knowledge production. This emphatically includes professional, informal and local/indigenous knowledge production. An example would be the increasing importance of traditional healers in Africa, coupled to their further professionalisation. Actually, there is increasing recognition of non-academic knowledge production; compare the notion of a "third sector" of knowledge production in Western countries (Neubauer 2005) which includes consultancies, NGOs, patient associations. Third-sector knowledge productions occurs in developing countries as well, but in a more fragmented manner. There is a further kind of knowledge and knowledge production which is important everywhere, but particularly so in developing countries: Local knowledge, e.g. about how new technology is actually taken up in concrete situations and practices, including local knowledge about what works. And knowledge of actual situations and dynamics where poverty alleviation has to take place.

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[4] It is quite tempting in NIS studies to try and show how the various elements in the national system work towards a common (often political) goal. In fact, all the well-known concepts of systems theory (pattern maintenance/ homeostasis/ input– output processes) are too easily applied to the national system of innovation to prove this point. But the NIS concept then seems to presuppose the existence of strong institutions as well as strong inter-institutional relations. The relationality of the concept points to the value of linkages within the NIS – between academia and industry, between government-based research and academia and so on. However, it is much more common in African countries to find that their research and innovation systems are extremely fragile. (Teng-Zeng and Mouton 2006)

What we advocate here (and show the building blocks of) is an evolutionary systems approach. This is interesting in its own right, and might lead to a better understanding of modern research systems and their further evolution as well. For example, there are strong path dependencies, already within Europe: the national systems in North-West Europe are different from Southern Europe (France, Italy, Spain), even if one can also inquire into their convergence. The study of path-dependencies is important to be able to see what changes are feasible, in contrast to the policy bravura of claiming to transform the system, somehow (the Lisbon objectives of the European Union are a case in point, but the phenomenon occurs all the time, in the large and in the small).

The study of actual and emerging path dependencies is even more important outside the TRIAD or OECD countries. At least three types of countries and KRIS-trajectories might be distinguished:

(1) The BRIC countries: China, and India, and possibly also Brasil and Russia (big and therefore powerful).[5]

(2) developing countries with emerging KRIS. These include other South American countries, South-East Asian countries,[6] and some bigger, better equipped African countries (South Africa, Egypt, Kenya, Nigeria)

(3) the poorest countries with what one could call a subsistence version of KRIS.

What can be said positively about subsistence KRIS? One entrance point is to look at informal knowledge flows and their uses. It is important to have such an entrance point because of strong claims about the heritage of colonialism and about being condemned to the periphery, as an argument for support or special treatment. Thus, one effect of post-colonialism is the ideology of redress, with its implication that the country has a need (and a right) to get up to the mark – the mark being defined by the former colonizing countries! The other route is to celebrate (beyond reason) the own heritage, as was attempted in the so-called African Renaissance movement. Both responses tend to overlook the actual dynamics and possibilities of the national (or regional) KRIS. Of course, there is no simple autonomy. There are global dependencies and asymmetries. But there also own dynamics that can be nurtured (even if one should probably be modest in one's claims).

Part II: Growing your own system

While there may be some doubts how applicable the system approach is to the complexities of the real world, the overall approach emphasizing mutual dependencies and evolving paths is clearly productive. In countries with little activities and therefore also few interdependencies, the system approach has not yet a strong empirical reference, but it may be used to sketch a desirable future. In other words, the notion of a system has also a normative aspect: having some system is better than having none at all.

[5] The discussion often focuses on emerging economic power, but there are developments in R&D investments, in training of scientists and engineers, and in innovation as well.
[6] See also papers from Asielics 2004 conference.

One indicator of such a use of a systems approach is how African countries now attempt to review their "science and technology systems" (Mugabe 2005 mentioning Botswana, Democratic Republic of Congo, Kenya, Nigeria, Rwanda and Uganda – countries like South Africa and Egypt have a longer history of reviewing their "system").

The next step is to explore how and why some systems are better than others. And whether some developmental paths in the present situation are better than others. There is a variety of paths, not limited to that of modern research system. How then to go about the next step: building blocks and design criteria for Knowledge, Research and Innovation Systems and modifications to developmental paths? If one starts with what is actually happening, and how this can be used and further improved, a number of building blocks for analysis and diagnosis can be identified.

First, Bertelsen and Müller (2003) emphasize the "social carrier of innovation" and show in case studies of village blacksmiths and indigenous boat building in Tanzania that local innovation occurs, and that innovative transformations include exogenous technological inputs. In other words, there is no complete distinction between a modern, formal sector taking up exogenous technology, and a local, informal sector working only with indigenous technology. There are interactions, learning, and the formal sector might profit from the way the informal sector adopts and assimilates exogenous technology. They conclude that it is important to recognize "the actual existence and change readiness of indogenous technologists" while avoiding "to indulge in craftsmanship nostalgia" (p. 136).

Second, one can broaden the science side of the equation (or better, lack of equation) by including other kinds of robust knowledge production, and thus other institutional and informal locations of knowledge production. This can be argued in general, and for specific issues like water management and poverty alleviation. A further step then is that actual and potential subterraneous links between science/knowledge production and technology/innovation become visible.

Third, intermediaries (of various nature) can and should play a role. There is recognition of the increasing importance of intermediaries in research & innovation systems in all countries (cf. also CREST's 2005 study for the Carnegie Foundation, which included an inventory of intermediaries in South Africa). And now also consideration of new or alternative intermediaries, similar to the role of NGOs and critical groups in developed countries. In developing countries, one sees similar developments, including experiments with intermediaries which links to local communities. An example would be the collaboration between NGOs and reseach groups in universities and institutes for participatory rural development.

We have insights and building blocks here that can be applied to the evaluation of current attempts to improve KRIS and to design suggestions for further/other improvement. By way of example, there is the current interest in Centres of Excellence, worldwide, and also in Africa (Mugabe 2005, African's Science and Technology Consolidated Plan of Action). The idea of distributed centres and networks of centres is interesting, e.g. the NEPAD Biosciences Network consisting of leading laboratories in biosciences in Egypt, Kenya, South Africa and Senegal. But there appears to be a bias towards "high" science and technology, where it is easier to recognize excellence.

To counteract the tendency, and avoid overlooking opportunities, it is useful to always speak (and think in terms) of Centres for Excellence and Relevance. This combination is possible in our era of strategic research and increasingly visible (Rip 2004). The combination can be used to argue for adding relevance to excellence, but also the other way round: show that relevance can be excellent (this resembles the ideas about Mode 2 of knowledge production, especially about 'discovery in the context of application). And further, that this possible also outside "high" science and technology.

Concretely, we can identify, and push for, the possibility of "low" Science & Technology Centres in addition to high Science & Technology Centres. The program on securing and sustaining water in the new African Consolidated Plan might have such components. The emancipation and professionalisation of traditional healers could lead to centres of training and investigation, which focus on other styles of knowledge production than experimental and quasi-experimental research, but produce robust knowledge nevertheless.

A particularly interesting possibility would be centres focusing on dynamics of adaptation and societal embedding of new technology (whether exogenous or endogenous). There have been calls to pay attention to the innovative elements in such processes ("innofusion"), but the problem continues to be seen as an implementation problem, not as a topic in its own right. Critical development studies have pointed out the limitations in the way new technologies are introduced; their insights could now be used to support constructive studies. Together, this would constitute a cluster of topics where global excellence is possible without losing relevance.

Naturally, there are many issues and challenges for growing your "own" Knowledge, Research and Innovation System. In particular, there is the dependence on donors, and thus too little endogenous development. This includes segmentation: health sector oriented to one set of donors, agricultural to another set, and little communication within the country (e.g. in Mali).Then, 'nations' in Africa are not strong, and if there is science, technology and innovation policy making, it is not necessarily implemented. Thirdly, the neglect of the informal sector, and for a combination of cultural and political reasons. But it is almost impossible (in a sense, by definition) to include the informal sector in centrally made and authorized plans.

Finally, there is the intrinsic challenge of action for improvement. Good ideas about a productive Knowledge, Research and Innovation Systems will not be realized just because they are good. And modulation of what is going on anyway is the best one can often do. There is the structural tension between top-down action (far away of what is happening, but able to keep goals visible and provide direction) and bottom-up action (close to what is happening, but then also a victim of it). Their interaction, or co-evolution, can be a locus for introducing change.

Part III. Constraints and opportunities to grow your own KRIS

Improving your own system is a long-term challenge, to be addressed while immediate problems cry out for attention and often get priority. System evolution is mostly a side-effect (at the collective level) of short-term projects. Is it possible to do better? What sort

of competencies have to be in place? And which constraints have to be taken into account, particularly those referred to as "globalization"?

Analysis of global movements and trends indicates that most countries will be at best temporary locations for activities shaped by transnational entities (from big companies to big charitable foundations). Only the new 'big boys' (India, China) can determine their future to some extent. There is a local/regional dynamic enabling added value through proximity, but this is still connected to the global system (cf. Grabher on local buzz and global pipelines).

"Growing your own system" will then depend on the openings left to the country by the global system (across the range of raw materials, manufacturing, and service). The bigger and emerging countries might profit from such openings (cf. Brazil, perhaps South-Africa). Even there, the challenge is to have such ventures contribute to growing an own KRIS. For subsistence countries (cf. Urugay, which has 58 physicists), there is no way to carve out a niche in the global system. They have to go back to basics, in all senses of this phrase.

Mazzoleni and Nelson (2007) discuss the possibilities of 'catching up' by developing countries, arguing that studies of economic catch-up in the past are of little value because circumstances are different now. Build-up of indigenous technological and scientific capabilities remains important, but should not take present-day scientific frontiers as its reference. They advocate niches where knowledge institutions and user communities interact, and a focus on application-oriented sciences and engineering disciplines. This is like our point about Centres of Excellence and Relevance, but without reference to an evolving KRIS.

A further entrance point which we emphasize is the importance of informal, often local knowledge (this includes indigenous knowledge but is not limited to it). This is key to productive work and innovation, and even subsistence countries can do well here if they can bracket the orientation to high science and formal institutions. It is less clear how this can be built up, over time, into a KRIS which can deliver more ambitious services to the country.

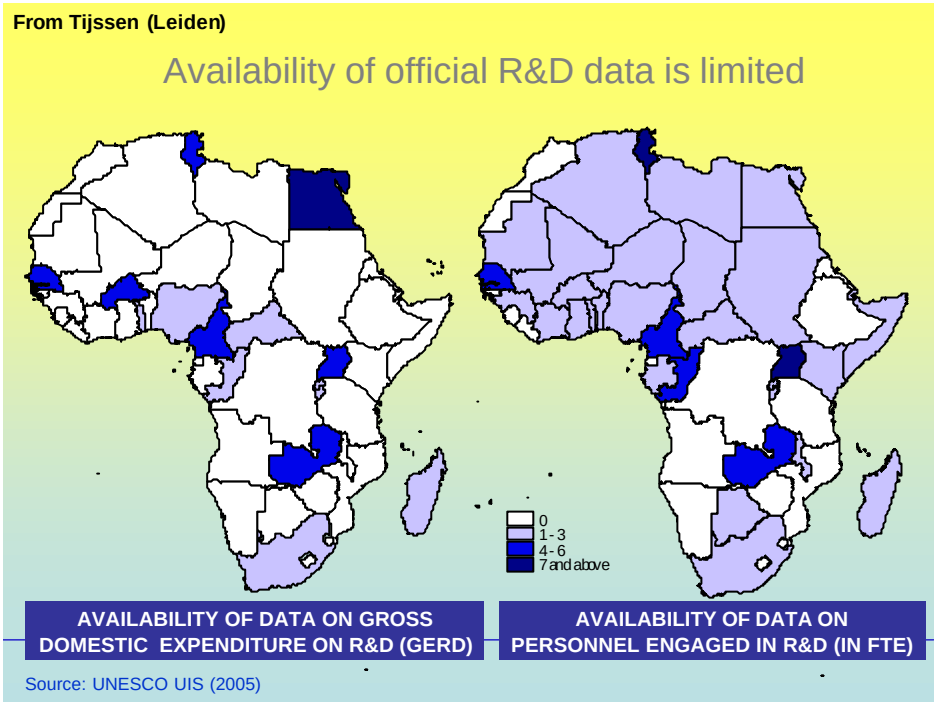
This is not something that can be resolved by further analysis. Experiments in growing your own KRIS are needed which are well prepared and closely monitored.

The other key question is about competencies. Not just competencies in doing science and innovation, but also competencies at the system level, including monitoring and modulating. We will limit ourselves to a brief discussion of what can be done by scholars and policy makers (at various levels), in order to propose some studies and experiments.

A necessary step (and ongoing effort) is mapping and diagnosing the system.[7] Basic statistics, of course, but also qualitative data, and the mapping & monitoring should be done in interaction with relevant actors, while recognizing governance issues (including interest and power politics).

[7] This can be put in a broader context by recognizing it as co-evolutionary paths becoming more reflexive, e.g. through "strategic intelligence" provided by STI scholars and actors collecting and interpreting data (Kuhlmann et al. 1999).

Already at the level of direct indicators, there are lacunae (cf. Figure below). Because of stakeholders and politics, collecting indicators is not simple, and is not enough. This is a further reason to build capacity in STI analysis and studies.



Secondly, case studies are necessary which allow understanding of dynamics and identification of opportunities, both to learn from them and to use them as examples which can stimulate action. Of course, it is an intellectual challenge how to learn systematically from case studies – but that can be done, and we actually envisage projects supporting interactive learning processes.

A project that can be (and should be) started up is monitoring and case studies in/of national and regional KRIS in African countries. It is to be shaped as an interactive learning process, where a first-round and still open-ended conceptualization is used for national or regional case studies.[8] Experiences and results will lead to modifications (comparisons will help!), which will be used in a next round, where specific challenges might be addressed. There are (just) enough African scholars and analysts, in centres with enough mass, to do such a job in interaction with STI scholars from Europe and the USA.

[8] Case studies can have different scope: national, sometimes regional, or with a focus on a sector or particular scientific/application domains.

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